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Ahn et al.

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(54) **MICRO MULTI-ARRAY HEATER AND MICRO MULTI-ARRAY SENSOR**

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(71) Applicant: **Point Engineering Co., Ltd.**, Asan-si, Chungcheongnam-do (KR)

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(72) Inventors: **Bum Mo Ahn**, Suwon-si (KR); **Seung Ho Park**, Hwaseong-si (KR); **Sung Hyun Byun**, Hwaseong-si (KR)

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(73) Assignee: **Point Engineering Co., Ltd.**, Asan-si, Chungcheongnam-do (KR)

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Primary Examiner — Robert R Raeviss

(74) *Attorney, Agent, or Firm* — Sunstein Kann Murphy & Timbers LLP

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(57) **ABSTRACT**

A micro multi-array heater and a micro multi-array sensor provided with the micro multi-array heater are provided. The micro multi-array heater includes a substrate and a heater electrode formed on the substrate. The heater electrode includes a first heater electrode having a first heat generation pattern and a second heater electrode having a second heat generation pattern. The first heat generation pattern and the second heat generation pattern are formed to have different heat generation amounts.

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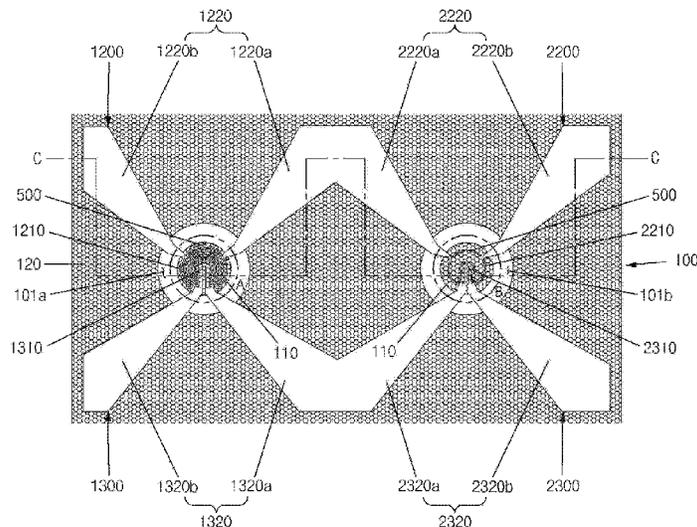
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17 Claims, 6 Drawing Sheets

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Fig. 1

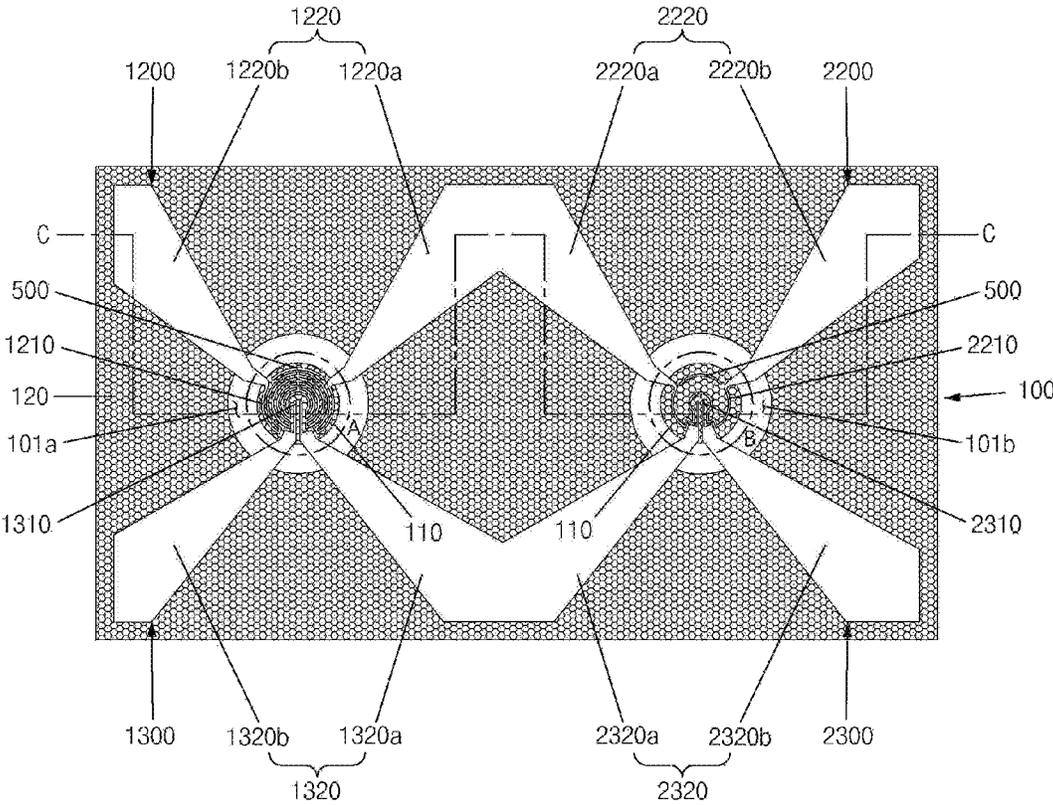


Fig. 2

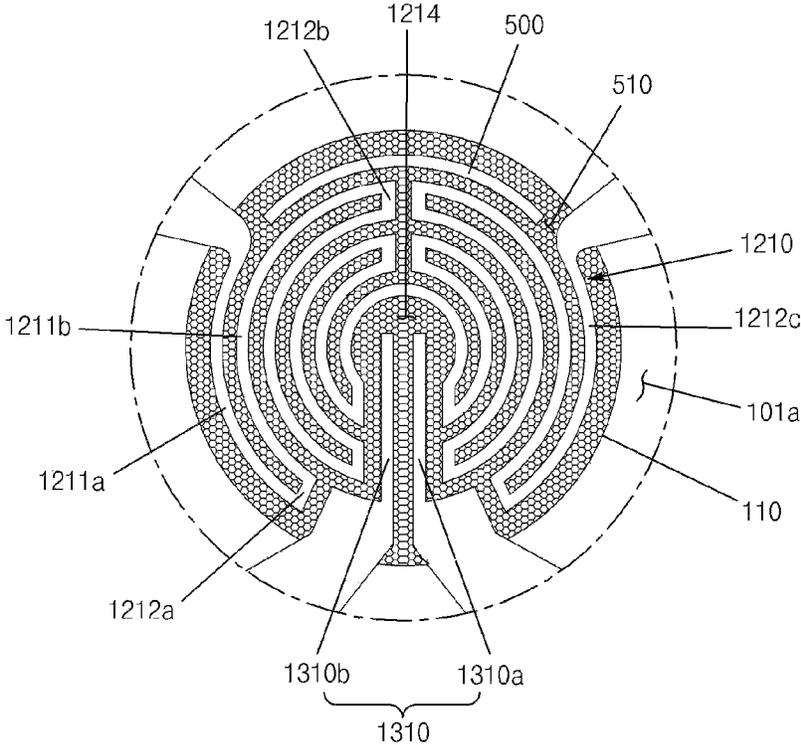
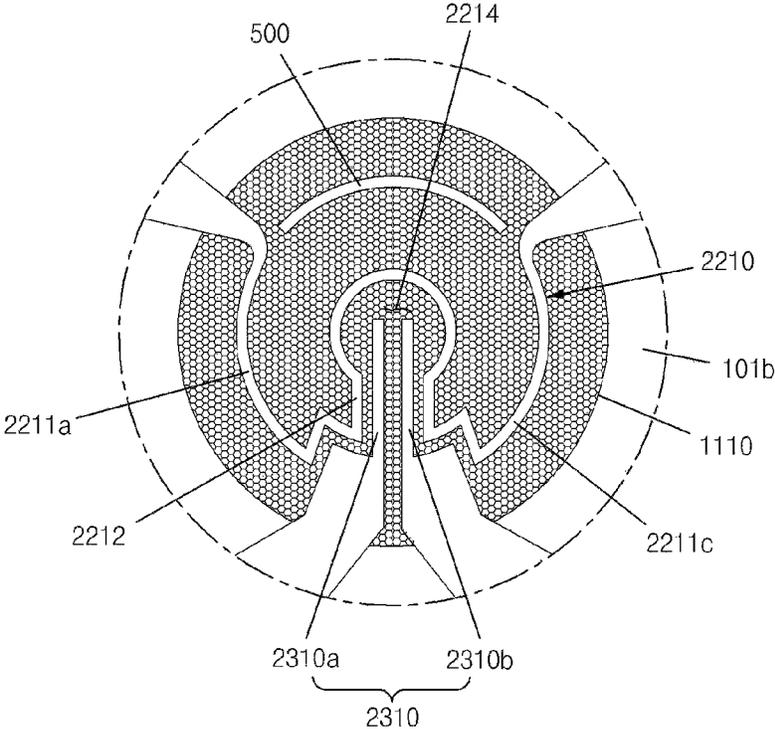


Fig. 3



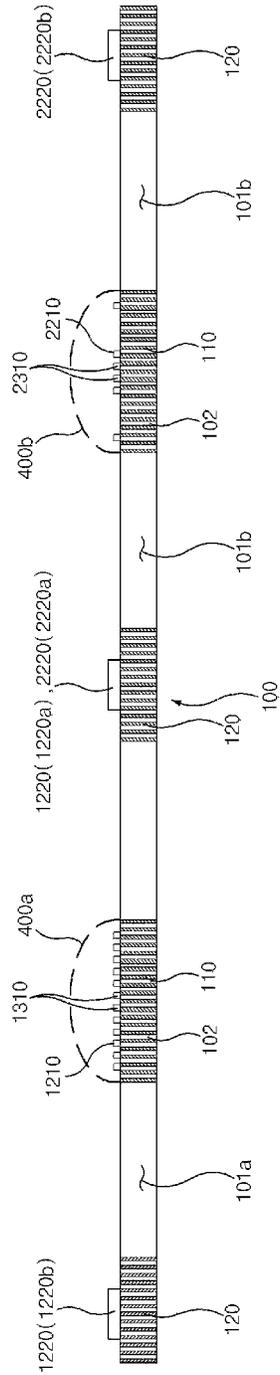


Fig. 4

Fig. 5

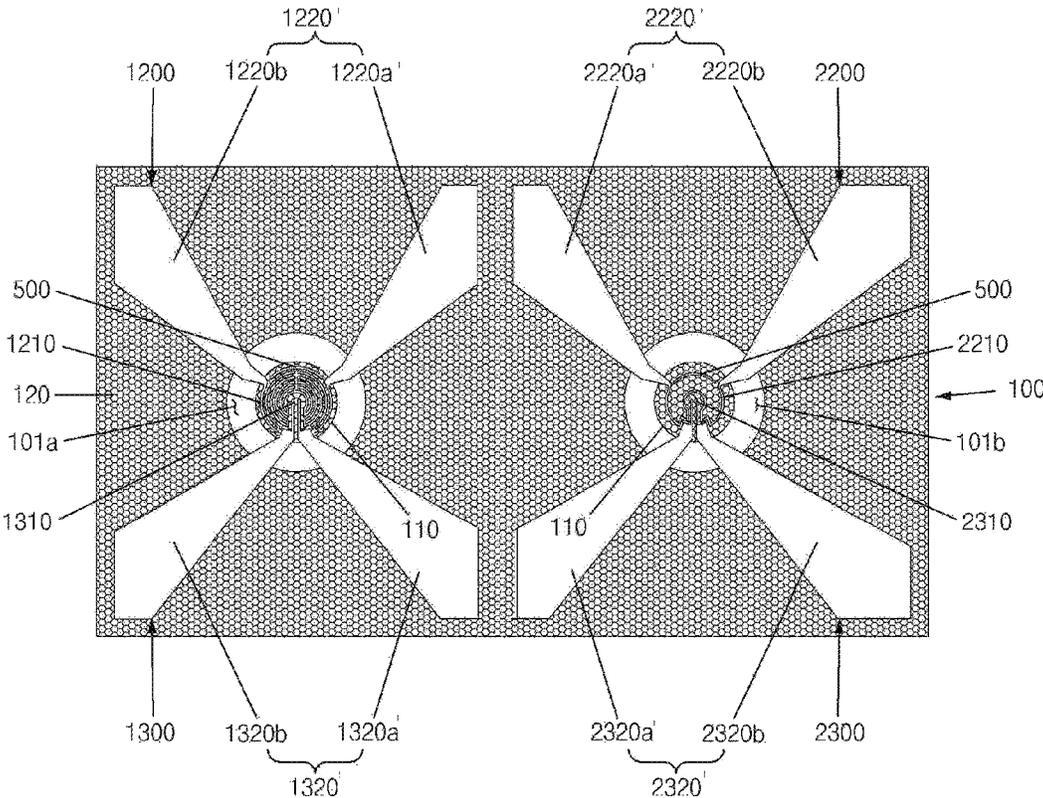
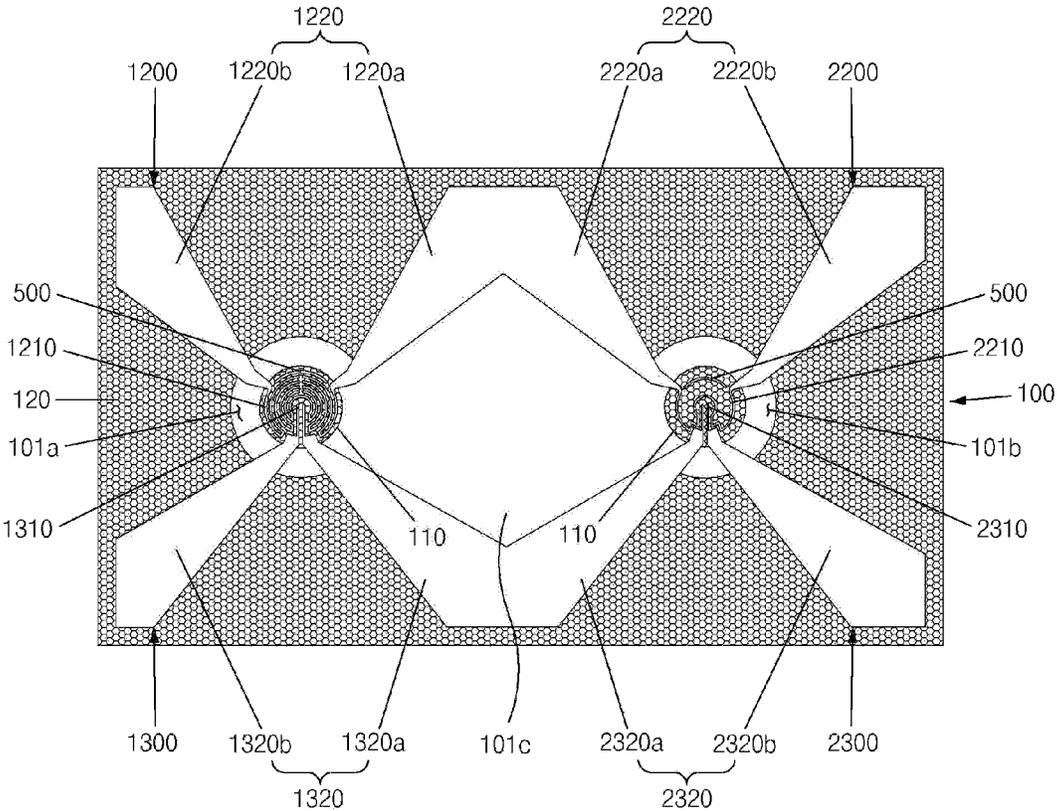


Fig. 6



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MICRO MULTI-ARRAY HEATER AND MICRO MULTI-ARRAY SENSOR

CROSS-REFERENCE TO RELATED PATENT APPLICATION

This U.S. non-provisional patent application claims priority under 35 U.S.C. § 119 of Korean Patent Application No. 10-2016-0083417 filed on Jul. 1, 2016 in the Korean Patent Office, the entire contents of which are hereby incorporated by reference.

TECHNICAL FIELD

The present invention relates to a micro multi-array heater and a micro multi-array sensor. More particularly, the present invention pertains to a micro multi-array heater provided with a first heater electrode and a second heater electrode which are different in heat generation amount, and a micro multi-array sensor.

BACKGROUND

As an interest on an environment gradually increases in recent years, a demand has existed for the development of a small-size sensor capable of accurately obtaining different kinds of information within a short period of time. Particularly, for the purpose of making a residential space pleasant, coping with a harmful industrial environment and managing a production process of beverage and foodstuff, efforts have been made to achieve the size reduction, precision enhancement and price reduction of a micro multi-array sensor such as a gas sensor for easily measuring a gas concentration or the like.

The currently available gas sensor gradually evolves from a ceramic-sintered gas sensor or a thick-film-type gas sensor to a micro gas sensor having the form of a micro electro mechanical system (MEMS) due to the application of a semiconductor process technique.

From the viewpoint of a measurement method, a method of measuring a change in the electric characteristics of a sensing material of a sensor when a gas is adsorbed to the sensing material is most frequently used in the currently available gas sensor. Typically, a metal oxide such as SnO₂ or the like is used as the sensing material to measure a change in the electrical conductivity depending on the concentration of a measurement target gas. This measurement method has an advantage in that it is relatively easy to use the method. A change in the measurement value becomes conspicuous when the metal oxide sensing material is heated to and operated at a high temperature. Accordingly, accurate temperature control is essential in order to rapidly and accurately measure a gas concentration. Furthermore, the gas concentration is measured after the sensing material is reset or restored to an initial state by forcibly removing gas species or moisture already adsorbed to the sensing material through high-temperature heating.

However, such a conventional sensor is configured to detect one kind of gas. In order to detect plural kinds of gases, there is a need to provide several sensors. This poses a problem in that the volume grows larger and the power consumption increases.

SUMMARY

According to one aspect of the present invention, there is provided a multi-array heater, including: a substrate; and a

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heater electrode formed on the substrate, wherein the heater electrode includes a first heater electrode having a first heat generation pattern and a second heater electrode having a second heat generation pattern, and the first heat generation pattern and the second heat generation pattern are formed to have different heat generation amounts.

In the micro multi-array heater, the first heat generation pattern and the second heat generation pattern may be connected in parallel.

In the micro multi-array heater, the first heat generation pattern and the second heat generation pattern may be formed to have different lengths.

In the micro multi-array heater, the first heat generation pattern and the second heat generation pattern may be formed to have different thicknesses.

In the micro multi-array heater, at least one air gap disposed between the first heat generation pattern and the second heat generation pattern may be formed in the substrate.

In the micro multi-array, the air gap may include a first air gap surrounding the first heat generation pattern and a second air gap surrounding the second heat generation pattern.

In the micro multi-array heater, the air gap may include a third air gap communicating with the first air gap and the second air gap, and the third air gap may be disposed between the first heat generation pattern and the second heat generation pattern.

In the micro multi-array heater, the air gap may be a space formed to extend from an upper surface of the substrate to a lower surface of the substrate.

In the micro multi-array heater, the substrate may be an anodic oxide film obtained by anodizing a metallic base material and then removing the base material.

In the micro multi-array heater, a dummy metal may be formed on the substrate so as to be disposed between the air gap and the first heat generation pattern or the second heat generation pattern.

According to another aspect of the present invention, there is provided a micro multi-array sensor, including: a substrate; a sensor electrode formed on the substrate; and a heater electrode formed on the substrate, wherein the sensor electrode includes a first sensor electrode having a first sensor wiring and a second sensor electrode having a second sensor wiring, the heater electrode includes a first heater electrode having a first heat generation pattern and a second heater electrode having a second heat generation pattern, the first sensor wiring is disposed more adjacent to the first heat generation pattern than the second heat generation pattern, the second sensor wiring is disposed more adjacent to the second heat generation pattern than the first heat generation pattern, and the first heat generation pattern and the second heat generation pattern are formed to have different heat generation amounts.

In the micro multi-array sensor, the first heat generation pattern and the second heat generation pattern may be connected in parallel.

In the micro multi-array sensor, the first heat generation pattern and the second heat generation pattern may be formed to have different lengths.

In the micro multi-array sensor, the first heat generation pattern and the second heat generation pattern may be formed to have different thicknesses.

In the micro multi-array sensor, at least one air gap disposed between the first heat generation pattern and the second heat generation pattern may be formed in the substrate.

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In the micro multi-array sensor, the air gap may include a first air gap surrounding the first heat generation pattern and a second air gap surrounding the second heat generation pattern.

In the micro multi-array sensor, the air gap may include a third air gap communicating with the first air gap and the second air gap, and the third air gap may be disposed between the first heat generation pattern and the second heat generation pattern.

In the micro multi-array sensor, the air gap may be a space formed to extend from an upper surface of the substrate to a lower surface of the substrate.

In the micro multi-array sensor, the substrate may be an anodic oxide film obtained by anodizing a metallic base material and then removing the base material.

In the micro multi-array sensor, a dummy metal may be formed on the substrate so as to be disposed between the air gap and the first heat generation pattern or the second heat generation pattern.

According to the micro multi-array heater and the micro multi-array sensor of the present invention described above, the following effects may be achieved.

The micro multi-array heater is provided with the first heater electrode and the second heater electrode which are different in heat generation amount. By applying the micro multi-array heater to a gas sensor, it is possible to simultaneously detect plural kinds of gases with a simple structure.

The first heat generation pattern and the second heat generation pattern are connected in parallel. The same voltage is applied to the first heat generation pattern and the second heat generation pattern. Thus, the micro multi-array heater may be applied to a product such as a mobile communication device or the like which can be driven at a low voltage and which requires use of low electric power.

The first heat generation pattern and the second heat generation pattern may be formed to have different lengths or to have different thicknesses. Thus, the heat generation amounts of the two heat generation patterns can be made different with a simple structure.

At least one air gap is formed in the substrate and is disposed between the first heat generation pattern and the second heat generation pattern so that the first heat generation pattern and the second heat generation pattern are thermally insulated from each other. Thus, even if two heat generation patterns are formed in one substrate and even if the heat generation temperatures of the two heat generation patterns are made different, it is possible to effectively maintain the respective heat generation temperatures and to accurately detect plural kinds of gases.

The air gap includes the first air gap surrounding the first heat generation pattern and the second air gap surrounding the second heat generation pattern. Thus, the heat capacity is reduced so that a high temperature can be maintained with low electric power.

The air gap further includes a third air gap communicating with the first air gap and the second air gap. The third air gap is disposed between the first heat generation pattern and the second heat generation pattern. This makes it possible to effectively insulate the first heat generation pattern and the second heat generation pattern.

The air gap is a space formed so as to extend from the upper surface of the substrate to the lower surface thereof. This makes it possible to maximize the thermal insulating effect.

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The substrate is an anodic oxide film obtained by anodizing a metallic base material and then removing the base material. This makes it possible to further enhance the thermal insulating effect.

The dummy metal is formed on the substrate so as to be disposed between the air gap and the first heat generation pattern or the second heat generation pattern. Thus, the temperature uniformity of the first support portion is improved.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a micro multi-array sensor provided with a micro multi-array heater according to a preferred embodiment of the present invention.

FIG. 2 is an enlarged view of an A region in FIG. 1.

FIG. 3 is an enlarged view of a B region in FIG. 1.

FIG. 4 is a sectional view taken along line C-C in FIG. 1.

FIG. 5 is a plan view of a micro multi-array sensor provided with a micro multi-array heater according to another preferred embodiment of the present invention.

FIG. 6 is a plan view of a micro multi-array sensor provided with a micro multi-array heater according to a further preferred embodiment of the present invention.

DETAILED DESCRIPTION

Preferred embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

For reference, in the following description, the same configurations of the present invention as those of the related art will not be described in detail. Reference is made to the foregoing description of the related art.

As shown in FIGS. 1 to 4, the micro multi-array sensor provided with a micro multi-array heater of the present embodiment includes a substrate **100**, a sensor electrode formed on the substrate **100**, and a heater electrode formed on the substrate **100**. The sensor electrode includes a first sensor electrode **1300** having a first sensor wiring (pattern) **1310** and a second sensor electrode **2300** having a second sensor wiring (pattern) **2310**. The heater electrode includes a first heater electrode **1200** having a first heat generation pattern **1210** and a second heater electrode **2200** having a second heat generation pattern **2210**. The first sensor wiring **1310** is disposed more adjacent to the first heat generation pattern **1210** than the second heat generation pattern **2210**. The second sensor wiring **2310** is disposed more adjacent to the second heat generation pattern **2210** than the first heat generation pattern **1210**. The first heat generation pattern **1210** and the second heat generation pattern **2210** are formed so as to have different heat generation amounts.

If a metallic base material is anodized, there is formed an anodic oxide film including a porous layer having a plurality of pores formed on a surface thereof and a barrier layer existing under the porous layer. In this regard, the metallic base material may be aluminum (Al), titanium (Ti), tungsten (W), zinc (Zn) or the like. It is preferred that the metallic base material is made of aluminum or aluminum alloy which is lightweight, easy to process, superior in heat conductivity and free from contamination of heavy metal.

For example, by anodizing a surface of an aluminum material, it is possible to form an aluminum oxide film including an aluminum oxide porous layer having a plurality of pores **102** formed on a surface thereof and a barrier layer existing under the aluminum oxide porous layer. The substrate **100** according to the preferred embodiment of the

present invention may be formed of, for example, only an aluminum oxide film from which aluminum is removed. An electrode may be formed on the aluminum oxide porous layer of the aluminum oxide film. Alternatively, an electrode may be formed on the barrier layer. In addition, the barrier layer of the aluminum oxide film may be removed so that the substrate **100** is formed of only the aluminum oxide porous layer having pores **102** vertically penetrating the substrate **100**.

The following description will be made based on the substrate **100** from which the aluminum and the barrier layer are removed as shown in FIG. 4.

The aluminum and the barrier layer are removed from the anodized aluminum material. Thus, the pores **102** vertically penetrate the substrate **100**. Since the substrate **100** is formed of the aluminum oxide porous layer, the micro multi-array heater has a small heat capacity.

The substrate **100** includes at least two first support portions **110** formed in a cylindrical shape in both side areas of the substrate **100**, a second support portion **120** formed outside the first support portions **110** in a spaced-apart relationship with the first support portions **110**, and a plurality of bridge portions configured to connect the first support portions **110** and the second support portion **120**. A large number of air gaps are formed account the first support portions **110**, namely between the first support portions **110** and the second support portion **120**. In the present embodiment, two first support portions **110** are formed in one substrate **100**. However, the number of the first support portions **110** may be three or more. The respective first support portions **110** are spaced apart from each other.

The air gaps includes first air gaps **101a** surrounding the periphery of the first support portion **110** disposed on the left side and second air gaps **101b** surrounding the periphery of the first support portion **110** disposed on the right side.

A large number of air gaps are formed around the first support portions **110**. The air gaps may be discontinuously formed. The air gaps and the bridge portions are alternately disposed along the periphery of each of the first support portions **110**. The bridge portions are formed by etching the periphery of each of the first support portions **110** and discontinuously forming the air gaps. One ends of the bridge portions are connected to each of the first support portions **110**, and the other ends of the bridge portions are connected to the second support portion **120**.

Hereinafter, description will be made on the sensor electrode, the heater electrode and a dummy metal **500** formed on the substrate **100**.

The sensor electrode is formed on the upper surface of the substrate **100**. The sensor electrode detects a gas by detecting a change in electrical characteristic when a gas is adsorbed to a sensing material.

The sensor electrode includes a first sensor electrode **1300** and a second sensor electrode **2300**. The first sensor electrode **1300** includes a first sensor wiring **1310** formed on the upper surface of the first support portion **110** disposed on the left side, a bridge portion connected to the first sensor wiring **1310**, and a first sensor electrode pad **1320** formed in the second support portion **120**.

The first sensor wiring **1310** includes a first sensor wiring first connection portion **1310a** and a first sensor wiring second connection portion **1310b**.

The first sensor wiring first connection portion **1310a** and the first sensor wiring second connection portion **1310b** are formed in the same shape and are spaced apart from each other in a left-right direction. The first sensor wiring first

connection portion **1310a** and the first sensor wiring second connection portion **1310b** are formed to linearly extend in an up-down direction.

The first sensor electrode pad **1320** includes a first sensor electrode first pad **1320a** connected to the first sensor wiring first connection portion **1310a**, and a first sensor electrode second pad **1320b** connected to the first sensor wiring second connection portion **1310b**. The distal end of the first sensor electrode first pad **1320a** is disposed more adjacent to the first support portion **110** disposed on the right side than the distal end of the first sensor electrode second pad **1320b**.

The first sensor electrode pad **1320** is formed so as to have a larger width than the first sensor wiring **1310**. The first sensor electrode pad **1320** is formed so that the width thereof grows wider toward the distal end thereof.

The first sensor electrode **1300** and the second sensor electrode **2300** are made of one of Pt, W, Co, Ni, Au and Cu or a mixture thereof.

The second sensor electrode **2300** is formed in the same shape as the first sensor electrode **1300**. The second sensor electrode **2300** includes a second sensor wiring **2310** formed on the upper surface of the first support portion **110** disposed on the right side, a bridge portion connected to the second sensor wiring **2310**, and a second sensor electrode pad **2320** formed in the second support portion **120**.

The second sensor wiring **2310** includes a second sensor wiring first connection portion **2310a**, and a second sensor wiring second connection portion **2310b**.

The second sensor electrode pad **2320** includes a second sensor electrode first pad **2320a** connected to the second sensor wiring first connection portion **2310a**, and a second sensor electrode second pad **2320b** connected to the second sensor wiring second connection portion **2310b**. The distal end of the second sensor electrode first pad **2320a** is disposed more adjacent to the first support portion **110** disposed on the left side than the distal end of the second sensor electrode second pad **2320b**. The distal end of the second sensor electrode first pad **2320a** is connected to the distal end of the first sensor electrode first pad **1320a**.

In the case where the intermediate portion between the second sensor electrode first pad **2320a** and the first sensor electrode first pad **1320a** is used as a common electrode, the first sensor electrode **1300** and the second sensor electrode **2300** are connected in parallel.

The heater electrode is formed on the upper surface of the substrate **100**.

When the electrodes are formed on the aluminum oxide porous layer of the aluminum oxide film, the upper portions of the pores **102** positioned under the heater electrode and the sensor electrode are closed by the heater electrode and the sensor electrode. The lower portions of the pores **102** are also closed. Alternatively, when the electrodes are formed on the barrier layer of the aluminum oxide film, the upper portions of the pores **102** positioned under the heater electrode and the sensor electrode are closed. The lower portions of the pores **102** are opened. Alternatively, when the barrier layer of the aluminum oxide film is removed, the upper portions of the pores **102** positioned under the heater electrode and the sensor electrode are closed by the heater electrode and the sensor electrode. The lower portions of the pores **102** are opened. In this way, the heater electrode is formed on the aluminum oxide porous layer. This makes it possible to provide a micro multi-array sensor having a small heat capacity.

The heater electrode includes a first heater electrode **1200**, and a second heater electrode **2200** spaced apart from the first heater electrode **1200**.

The first heater electrode **1200** includes a first heat generation pattern **1210** disposed more adjacent to the first sensor wiring **1310** than the first sensor electrode pad **1320**, and a first heater electrode pad **1220** connected to the first heat generation pattern **1210** and formed in the second support portion **120** and the bridge portion.

The first heat generation pattern **1210** is formed on the first support portion **110** disposed on the left side and is formed so as to surround at least a part of the first sensor wiring **1310**. The first heater electrode pad **1220** includes a first heater electrode first pad **1220a** and a first heater electrode second pad **1220b** respectively connected to both ends of the first heat generation pattern **1210**. The first heater electrode first pad **1220a** and the first heater electrode second pad **1220b** are spaced apart from each other.

When seen in a plan view as shown in FIG. 2, the first heat generation pattern **1210** includes a plurality of arc portions formed in a circular arc shape so as to be symmetrical with respect to a vertical center axis of the first support portion **110**, and a plurality of connection portions configured to connect the arc portions.

The first heat generation pattern **1210** is formed so as to be spaced apart inward from the edge of the first support portion **110**.

The first heat generation pattern **1210** includes a first arc portion **1211a** disposed adjacent to the first air gaps **101a** and formed in a circular arc shape, a first connection portion **1212a** bent at one end of the first arc portion **1211a** so as to extend toward the inner side of the first support portion **110**, a second arc portion **1211b** formed in a circular arc shape so as to extend from an end of the first connection portion **1212a** and spaced apart inward from the first arc portion **1211a**, a second connection portion **1212b** formed so as to extend from an end of the second arc portion **1211b** toward the inner side of the first support portion **110**, a third arc portion **1211c**, etc. In this way, a plurality of arc portions and a plurality of connection portions are repeatedly connected to each other.

The first heat generation pattern **1210** is integrally formed by connecting the first arc portion **1211a**, the second arc portion **1211b** and the third arc portion **1211c** and is symmetrical with respect to the vertical center axis of the first support portion **110** disposed on the left side.

As shown in FIG. 2, the arc portions of the first heat generation pattern **1210** are formed in a substantially semi-circular arc shape and are symmetrical in a left-right direction. Thus, the first heat generation pattern **1210** forms a substantially circular shape as a whole. This makes it possible to improve the temperature uniformity of the first support portion **110**.

Two left and right arc portions meet with each other at the center of the first heat generation pattern **1210**. The two arc portions are connected to form a substantially circular shape opened on the lower side. A separation space portion **1214** is formed inside the two arc portions. The separation space portion **1214** is formed so as to extend from the center of the first heat generation pattern **1210** to the lower portion of the first heat generation pattern **1210**. That is to say, the left and right arc portions are spaced apart in the left-right direction so that the separation space portion **1214** is formed from the center of the first heat generation pattern **1210** to the lower portion of the first heat generation pattern **1210**. The first sensor wiring **1310** is disposed in the separation space portion **1214**. Thus, the first heat generation pattern **1210** surrounds the upper portion and the side portions of the first sensor wiring **1310**.

The first heater electrode second pad **1220b** is connected to the other end of the first arc portion **1211a**. The first heater electrode first pad **1220a** is connected to one end of the third arc portion **1211c**.

The first heater electrode **1200** may be made of one of Pt, W, Co, Ni, Au and Cu or a mixture thereof.

Meanwhile, a dummy metal **500** is formed between both ends of the first heat generation pattern **1210**, namely between the ends of the first arc portion **1211a** and the second arc portion **1211b** to which the first heater electrode first pad **1220a** and the first heater electrode second pad **1220b** are respectively connected.

The dummy metal **500** is disposed in a circular arc shape between the first heater electrode **1200**, i.e., the first heat generation pattern **1210** and the first air gaps **101a**. The dummy metal **500** is spaced apart from the first heat generation pattern **1210** adjacent thereto. The dummy metal **500** is spaced apart inward from the edge of the first support portion **110**.

It is preferred that the dummy metal **500** is formed outside the first heat generation pattern **1210** and is made of a metal. The material of the dummy metal **500** may be the same as the electrode material. The electrode material may be a metal such as platinum, aluminum, copper or the like.

As shown in FIG. 2, the first arc portion **1211a** and the third arc portion **1211c** are shorter in length than the remaining arc portions disposed inside thereof. In the outer periphery of the first heat generation pattern **1210**, a space **510** is formed between the ends of the first arc portion **1211a** and the third arc portion **1211c**. The dummy metal **500** is positioned in the space **510**. The width of the dummy metal **500** is equal to or similar to the width of the first heat generation pattern **1210**.

The space **510** existing in the outer periphery of the of the first heat generation pattern **1210** is partially filled with the dummy metal **500**. Thus, when seen in a plane view, the outer peripheries of the first heat generation pattern **1210** and the dummy metal **500** form a circle. This makes it possible to improve the temperature uniformity of the first support portion **110**.

The first heater electrode first pad **1220a** and the first heater electrode second pad **1220b** are formed so that the width thereof grows larger outward. In other words, the first heater electrode pad **1220** is formed so that the width thereof grows smaller toward the first heat generation pattern **1210**. The first heater electrode pad **1220** is formed so as to have a larger width than the first heat generation pattern **1210**. The first heater electrode first pad **1220a** is disposed more adjacent to the first support portion **110** disposed on the right side than the first heater electrode second pad **1220b**.

The second heater electrode **2200** is formed similarly to the first heater electrode **1200**. The second heater electrode **2200** includes a second heat generation pattern **2210** disposed more adjacent to the second sensor wiring **2310** than the second sensor electrode pad **2320**, and a second heater electrode pad **2220** connected to the first heat generation pattern **1210** and formed in the second support portion **120** and the bridge portion.

The second heat generation pattern **2210** is formed on the first support portion **110** disposed on the right side. Thus, the first sensor wiring **1310** and the first heat generation pattern **1210** are formed on the upper surface of the first support portion **110** disposed on the left side. The second sensor wiring **2310** and the second heat generation pattern **2210** are formed on the upper surface of the first support portion **110** disposed on the right side.

Accordingly, the first sensor wiring **1310** is disposed more adjacent to the first heat generation pattern **1210** than the second heat generation pattern **2210**. The second sensor wiring **2310** is disposed more adjacent to the second heat generation pattern **2210** than the first heat generation pattern **1210**.

The first heat generation pattern **1210** and the second heat generation pattern **2210** are formed to have different heat generation amounts.

In order to make the heat generation amounts of the first heat generation pattern **1210** and the second heat generation pattern **2210** different from each other, the first heat generation pattern **1210** and the second heat generation pattern **2210** may be formed to have different lengths as shown in FIG. **1** or may be formed to have different thicknesses.

In the present embodiment, the length of the first heat generation pattern **1210** is larger than the length of the second heat generation pattern **2210** so that a first sensing material **400a** formed on the upper surface of the first support portion **110** disposed on the left side can be heated to a higher temperature than a second sensing material **400b** formed on the upper surface of the first support portion **110** disposed on the right side. This enables the first sensor electrode **1300** and the second sensor electrode **2300** to detect different kinds of gases.

The first heat generation pattern **1210** is bent to have a smaller gap than the second heat generation pattern **2210**. Thus, the first heat generation pattern **1210** and the second heat generation pattern **2210** can be formed in limited areas (first support portions) so as to have different lengths.

Unlike the present embodiment, the first heat generation pattern and the second heat generation pattern may be formed so as not to be symmetrical with respect to the vertical center axis or the horizontal center axis of the first support portion **110**. That is to say, the first heat generation pattern and/or the second heat generation pattern may be formed by serially connecting two heat generation patterns bent in a mutually different shape.

The second heat generation pattern **2210** is formed on the first support portion **110** disposed on the right side and is formed so as to surround at least a part of the second sensor wiring **2310**. The second heater electrode pad **2220** includes a second heater electrode first pad **2220a** and a second heater electrode second pad **2220b** respectively connected to both ends of the second heat generation pattern **2210**. The second heater electrode first pad **2220a** and the second heater electrode second pad **2220b** are spaced apart from each other.

As seen in a plan view as shown in FIG. **3**, the second heat generation pattern **2210** is also formed so as to be symmetrical with respect to the vertical center line of the first support portion **110** disposed on the right side.

The second heat generation pattern **2210** is spaced apart inward from the edge of the first support portion **110**.

The second heat generation pattern **2210** includes a first arc portion **2211a** formed adjacent to the second air gaps **101b** so as to have a circular arc shape, a third arc portion **2211c**, and a sensor wiring surrounding portion **2212** formed between the first arc portion **2211a** and the third arc portion **2211c**.

The first arc portion **2211a** is connected to the second heater electrode first pad **2220a**, and the third arc portion **2211c** is connected to the second heater electrode second pad **2220b**.

The sensor wiring surrounding portion **2212** is connected to the lower ends of the first arc portion **2211a** and the third arc portion **2211c** and is formed in a curved shape so as to

surround the second sensor wiring **2310**. Thus, a separation space portion **2214** with an open lower end is formed in the sensor wiring surrounding portion **2212**.

An arc-shape dummy metal **500** is formed between both ends of the second heat generation pattern **2210**, namely between the ends of the first arc portion **2211a** and the third arc portion **2211c** to which the second heater electrode first pad **2220a** and the second heater electrode second pad **2220b** are respectively connected.

The dummy metal **500** formed on the upper surface of the first support portion **110** disposed on the right side has the same shape and effect as the dummy metal **500** formed on the upper surface of the first support portion **110** disposed on the left side. Thus, the detailed description thereof will be omitted.

In this manner, the dummy metal **500** is formed on the first support portion **110** of the substrate **100** between the first air gaps **101a** and the first heat generation pattern **1210**, and the dummy metal **500** is formed on the first support portion **110** of the substrate **100** between the second air gaps **101b** and the second heat generation pattern **2210**.

The second heater electrode first pad **2220a** and the second heater electrode second pad **2220b** are formed so that the width thereof grows larger outward. That is to say, the second heater electrode pad **2220** is formed so that the width thereof grows smaller toward the second heat generation pattern **2210**. The second heater electrode pad **2220** is formed so as to have a larger width than the second heat generation pattern **2210**.

The second heater electrode first pad **2220a** is disposed more adjacent to the first support portion **110** disposed on the left side than the second heater electrode second pad **2220b**.

The second heater electrode first pad **2220a** is connected to the first heater electrode first pad **1220a**.

In the case where the intermediate portion between the second heater electrode first pad **2220a** and the first heater electrode first pad **1220a** is used as a common electrode, the first heat generation pattern **1210** and the second heat generation pattern **2210** are connected in parallel.

Alternatively, if electric power is supplied to the first heater electrode **1200** or the second heater electrode **2200** in a state in which the second heater electrode first pad **2220a** and the first heater electrode first pad **1220a** are merely connected to each other without using the intermediate portion between the second heater electrode first pad **2220a** and the first heater electrode first pad **1220a** as a common electrode, the first heat generation pattern **1210** and the second heat generation pattern **2210** are connected in series.

As described above, in the heater electrode of the present embodiment, the first heat generation pattern **1210** and the second heat generation pattern **2210** may be connected in parallel or in series depending on the position at which electric power is supplied.

Unlike the above description, as shown in FIG. **5**, the second heater electrode first pad **2220a'** and the first heater electrode first pad **1220a'** may be formed so as to be separated from each other, and the second sensor electrode first pad **2320a'** and the first sensor electrode first pad **1320a'** may be formed so as to be separated from each other. When the first and second heater electrode pad **1220'** and **2220'** and the first and second sensor electrode pads **1320'** and **2320'** are formed so as to be separated from each other in this manner, it is possible to individually control the left sensor and the right sensor. Therefore, depending on the situations, only the left sensor may be turned on to detect a gas, or only the right sensor may be turned on to detect a gas.

The first and second heater electrode first pads **1220a** and **2220a** are disposed in the upper middle region of the substrate **100**. The first and second heater electrode second pads **1220b** and **2220b** are disposed in the upper side regions of the substrate **100**.

A discoloration-preventing protective layer (not shown) is formed on the entire upper surfaces of the heater electrode and the second sensor electrode. The discoloration-preventing protective layer may be made of an oxide-based material. Specifically, the discoloration-preventing protective layer may be made of at least one of tantalum oxide (TaO_x), titanium oxide (TiO₂), silicon oxide (SiO₂) and aluminum oxide (Al₂O₃).

Soldering metals are disposed at the ends of the first and second heater electrode pads **1220** and **2220** and the first and second sensor electrode pads **1320** and **2320**. The soldering metals are formed on the discoloration-preventing protective layer. The soldering metals may be at least one of gold, silver and tin.

The first air gaps **101a** surround the first heat generation pattern **1210**. The second air gaps **101b** surround the second heat generation pattern **2210**. In this manner, at least one air gap is formed between the first heat generation pattern **1210** and the second heat generation pattern **2210**.

The first air gaps **101a** and the second air gaps **101b** are formed in the same shape. The first air gaps **101a** and the second air gaps **101b** are formed to have a larger width than the pores **102**. Four first air gaps **101a** and four second air gaps **101b** are formed in a circular arc shape. The first air gaps **101a** and the second air gaps **101b** are spaced apart in the circumferential direction. That is to say, the first air gaps **101a** and the second air gaps **101b** are formed discontinuously in a plural number.

Specifically, the first air gaps **101a** are disposed between the first sensor electrode second pad **1320b** and the first heater electrode second pad **1220b**, between the first heater electrode second pad **1220b** and the first heater electrode first pad **1220a**, between the first heater electrode first pad **1220a** and the first sensor electrode first pad **1320a**, and between the first sensor electrode first pad **1320a** and the first sensor electrode second pad **1320b**.

The second air gaps **101b** are disposed between the second sensor electrode second pad **2320b** and the second heater electrode second pad **2220b**, between the second heater electrode second pad **2220b** and the second heater electrode first pad **2220a**, between the second heater electrode first pad **2220a** and the second sensor electrode first pad **2320a**, and between the second sensor electrode first pad **2320a** and the second sensor electrode second pad **2320b**.

In other words, the first air gaps **101a** and the second air gaps **101b** are formed in the regions other than the portions for supporting the first heater electrode **1200**, the second heater electrode **2200**, the first sensor electrode **1300** and the second sensor electrode **2300**.

The first air gaps **101a** and the second air gaps **101b** are formed to vertically penetrate the substrate **100**. In other words, the first air gaps **101a** and the second air gaps **101b** are spaces extending from the upper surface of the substrate **100** to the lower surface thereof.

Due to the existence of the first air gaps **101a** and the second air gaps **101b**, the left first support portion **110** configured to support the first heat generation pattern **1210** and the first sensor wiring **1310**, the right first support portion **110** configured to support the second heat generation pattern **2210** and the second sensor wiring **2310**, the second support portion **120** configured to support the first heater electrode pad **1220**, the second heater electrode pad **2220**,

the first sensor electrode pad **1320** and the second sensor electrode pad **2320**, and the bridge portions are formed in the substrate **100**.

Each of the first support portions **110** is formed so as to have a wider area than the total area of the heat generation pattern and the sensor wiring formed on each of the first support portions **110**.

The first support portion **110** and the second support portion **120** are spaced apart from each other by the air gaps in the regions other than the bridge portions. In other words, as shown in FIG. 1, the first support portion **110** and the second support portion **120** are connected to each other by the bridge portions at four points.

The second support portion **120** is disposed between the first air gaps **101a** and the second air gaps **101b** disposed between the left and right first support portions **110**. That is to say, the second support portion **120** is disposed between the first air gaps **101a** formed between the first heater electrode first pad **1220a** and the first sensor electrode first pad **1320a** and the second air gaps **101b** formed between the second heater electrode first pad **2220a** and the second sensor electrode first pad **2320a**. Thus, the left first support portion **110**, the first air gaps **101a**, the second support portion **120**, the second air gaps **101b** and the right first support portion **110** are sequentially disposed from the left side toward the right side.

Alternatively, as shown in FIG. 6, the air gaps may include a third air gap **101c** communicating with the first air gaps **101a** and the second air gaps **101b**. The third air gap **101c** may be disposed between the first heat generation pattern **1210** and the second heat generation pattern **2210**. That is to say, the third air gap **101c** is disposed between the first air gaps **101a** formed between the first heater electrode first pad **1220a** and the first sensor electrode first pad **1320a** and the second air gaps **101b** formed between the second heater electrode first pad **2220a** and the second sensor electrode first pad **2320a**. Thus, the substrate **100'** according to a further embodiment does not have the second support portion **120** in the region between the first air gaps **101a** formed between the first heater electrode first pad **1220a** and the first sensor electrode first pad **1320a** and the second air gaps **101b** formed between the second heater electrode first pad **2220a** and the second sensor electrode first pad **2320a**. Thus, the left first support portion **110**, the first air gaps **101a**, the third air gap **101c**, the second air gaps **101b** and the right first support portion **110** are sequentially disposed from the left side toward the right side. The third air gap surrounded by the left first support portion **110**, the first heater electrode first pad **1220a**, the second heater electrode first pad **2220a**, the right first support portion **110**, the second sensor electrode first pad **2320a** and the first sensor electrode first pad **1320a** is formed in the substrate **100'**.

A first sensing material **400a** and a second sensing material **400b** are formed on the first support portions **110**, respectively. The first sensing material **400a** and the second sensing material **400b** are formed at the positions corresponding to the first support portions **110**. The first sensing material **400a** covers the first heat generation pattern **1210** and the first sensor wiring **1310**. The second sensing material **400b** covers the second heat generation pattern **2210** and the second sensor wiring **2310**.

The first sensing material **400a** and the second sensing material **400b** may be made of the same material or different materials. Even if the same sensing material is used, different gases may be adsorbed to the sensing material depending on the heating temperature.

The first sensing material **400a** and the second sensing material **400b** are formed by printing. When the first sensing material **400a** and the second sensing material **400b** are formed by printing in this manner, a mesh-like mark is left on the surface of each of the first sensing material **400a** and the second sensing material **400b** after forming the first sensing material **400a** and the second sensing material **400b**.

The operations of the micro multi-array heater and the micro multi-array sensor according to the present embodiment configured as above will now be described.

In order to measure a gas concentration, first, electric power having the same level is simultaneously applied to the first heater electrode pad **1220** and the second heater electrode pad **2220** so that the first heat generation pattern **1210** and the second heat generation pattern **2210** can generate heat. Since the first heat generation pattern **1210** is longer than the second heat generation pattern **2210**, the first sensing material **400a** is heated to a higher temperature than the second sensing material **400b**.

Thus, different gases are adsorbed to or desorbed from the first sensing material **400a** and the second sensing material **400b**. Through such a process, the micro multi-array sensor according to the present embodiment can simultaneously detect plural kinds of gases.

While some preferred embodiments of the present invention have been described above, a person skilled in the relevant technical field will be able to differently change or modify the present invention without departing from the spirit and scope of the present invention defined in the claims.

What is claimed is:

1. A multi-array sensor with a multi-array heater comprising:
 - a substrate, which is an anodic oxide film including a porous layer, obtained by anodizing a metallic base material and then removing the base material; and
 - heater electrodes formed on the substrate, wherein the heater electrodes include a first heater electrode having a first heat generation pattern and a second heater electrode having a second heat generation pattern, and the first heat generation pattern and the second heat generation pattern are formed to have different heat generation amounts and different thicknesses.
2. The multi-array sensor with the multi-array heater of claim 1, wherein the first heat generation pattern and the second heat generation pattern are connected in parallel.
3. The multi-array sensor with the multi-array heater of claim 1, wherein the first heat generation pattern and the second heat generation pattern are formed to have different lengths.
4. The multi-array sensor with the multi-array heater of claim 1, wherein at least one air gap disposed between the first heat generation pattern and the second heat generation pattern is formed in the substrate.
5. The multi-array sensor with the multi-array heater of claim 4, wherein the air gap includes a first air gap sur-

rounding the first heat generation pattern and a second air gap surrounding the second heat generation pattern.

6. The multi-array sensor with the multi-array heater of claim 5, wherein the at least one air gap includes a third air gap connecting the first air gap with the second air gap.

7. The multi-array sensor with the multi-array heater of claim 4, wherein the air gap is a space formed to extend from an upper surface of the substrate to a lower surface of the substrate.

8. The multi-array sensor with the multi-array heater of claim 4, wherein a dummy metal is formed on the substrate so as to be disposed between the air gap and the first heat generation pattern or the second heat generation pattern.

9. The multi-array sensor with the multi-array heater of claim 1, further comprising:

- a sensor electrode formed on the substrate; and
- wherein the sensor electrode includes a first sensor electrode having a first sensor wiring and a second sensor electrode having a second sensor wiring,

- the first sensor wiring is disposed more adjacent to the first heat generation pattern than the second heat generation pattern,

- the second sensor wiring is disposed more adjacent to the second heat generation pattern than the first heat generation pattern.

10. The multi-array sensor with the multi-array heater of claim 9, wherein the first heat generation pattern and the second heat generation pattern are connected in parallel.

11. The multi-array sensor with the multi-array heater of claim 9, wherein the first heat generation pattern and the second heat generation pattern are formed to have different lengths.

12. The multi-array sensor with the multi-array heater of claim 9, wherein the first heat generation pattern and the second heat generation pattern are formed to have different thicknesses.

13. The multi-array sensor with the multi-array heater of claim 9, wherein at least one air gap disposed between the first heat generation pattern and the second heat generation pattern is formed in the substrate.

14. The multi-array sensor with the multi-array heater of claim 13, wherein the air gap includes a first air gap surrounding the first heat generation pattern and a second air gap surrounding the second heat generation pattern.

15. The multi-array sensor with the multi-array heater of claim 14, wherein the at least one air gap includes a third air gap connecting the first air gap with the second air gap.

16. The multi-array sensor with the multi-array heater of claim 13, wherein the air gap is a space formed to extend from an upper surface of the substrate to a lower surface of the substrate.

17. The multi-array sensor with the multi-array heater of claim 13, wherein a dummy metal is formed on the substrate so as to be disposed between the air gap and the first heat generation pattern or the second heat generation pattern.

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